Our Debt to Joseph Henry, Scientist

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THE name of Joseph Henry is connected with a brilliant epoch in the history of the science of electricity. Prior to this brilliant period Stephen Gray's discovery, in 1729, of electrical conduction laid a broad foundation for subsequent work, while Franklin's discoveries and philosophical speculations in the realm of electrical phenomena gave a tremendous impulse to further research. Galvani's fortunate discovery of the existence of electric force in the contact region of heterogeneous bodies closes the preliminary period. Substantial progress was made during the eighteenth century, but the progress was, comparatively speaking, slow and laborious. The intellectual atmosphere of the eighteenth century was rather heavy and quiescent, as if foreboding the approach of a mighty storm.

The storm arrived; the intellectual forces which, like a mountain torrent, broke loose during the French Revolution and threatened to unhinge every human structure, receded rapidly to their natural channels. The torrent seemed to have washed away every impediment to rapid intellectual progress, and in every line of human thought a vigorous advance was initiated. Volta (1799) discovered the voltaic cell and taught mankind how to generate larger quantities of electricity in motion. Oersted (1819) discovered the magnetic force exerted by electricity in motion, and Ampère a year later (1820) formulated the fundamental law connecting this magnetic force with the electrical motion producing it. We have here three giants, Volta, Oersted, and Ampère, accomplishing more in twenty years than had been accomplished in the science of electricity during the previous 2,500 years.

Helmholtz and Thomson pointed out many years ago that Oersted's discovery is much broader than Oersted or even Ampère ever suspected, and that it embraces phenomena which those men never dreamt of, the phenomena of electromagnetic induction; or, to use a more descriptive expression, the phenomena of electric forces gen-

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erated by the motion of magnetism. But to infer, from the existence of magnetic forces produced by moving electricity, the existence of electric forces produced by moving magnetism, it is necessary (as Helmholtz and Thomson point out) to have a clear vision of the principle of the conservation of energy. This vision did not appear until nearly thirty years after Oersted and Ampère had finished their work in electromagnetism. But even if this great principle had been formulated prior to the days of Oersted and Ampère, I doubt very much that the astuteness of any human brain would ever have gone so far as to infer, by pure logic, electromagnetic induction from electromagnetism. A logical deduction of this kind would stand today without a parallel in the history of human thought.

But Henry's experimental work and Faraday's experimental work had to be done, and their great discoveries had to be made, in the very manner in which those physicists made them, in order to reveal before our wondering eyes the beautiful phenomena of electromagnetic induction. Nature guards her secrets too well to reveal a whole world of startling phenomena to a man who makes no other effort than academic deduction by logic and pure reasoning. Our knowledge of physical phenomena advances by consecutive experimental steps; there was no direct line from Oersted and Ampère to Henry and Faraday. We had to wait for Arago, who demonstrated that electricity in motion magnetizes a steel needle, and we had to wait for Sturgeon, who subsequently, in 1823, showed that an electrical current circulating in a coil of wire wrapped around a horseshoe-shaped piece of steel made a magnet—a revolutionary discovery, the electromagnet. Henry was then a youth, twenty-four years old, tutoring in a private family in Albany, and in his leisure hours studying mathematics and reading such works as Lagrange's classical treatise on *Analytical Mechanics*. He had never had, up to this time, an instrument for research in his hands, but in less than five years he became the foremost authority, and practically the only authority, on electromagnets. At that time (this was prior to the discovery of electromagnetic induction) the science and the art of the electromagnet undoubtedly presented the biggest problem in physics, and the very fact that Henry chose this subject for his study proves that he was cast for a great physicist. Willard Gibbs, our great mathematical physicist, said once that the most essential difference between great and commonplace scientists is revealed in the quality of problems which they select. A great physicist knows a great physical problem when he sees it. The electromagnet was a great problem because it led to the discovery of electromagnetic induction; and this was the key, and the only key, that opened the door of the secret chamber within which nature guarded the secrets of electromagnetic induction. Henry found the key and he opened the door which revealed to our wondering eyes the phenomena of electromagnetic induction. At about the same time, and using the same key which Henry had invented, the electromagnet, Faraday, independently of Henry, opened the same door. There can be no doubt as to Henry's claim. Sturgeon said: "Henry has been enabled to produce a magnetic force which totally eclipsed every other in the annals of magnetism, and no parallel is to be found since the miraculous suspension of the celebrated oriental impostor in his iron coffin."

Henry worked day and night making electromagnets that could lift thousands of pounds. The magnets are still in existence at Princeton and at Yale. If the master-mind which constructed these magnets had not discovered electromagnetic induction, and at the very time when the discovery was made, the failure would have been a miracle far more wonderful than the discovery itself.

Henry, it is true, never pressed his claim seriously. But he never pressed a claim; he never claimed anything; he was as modest as an angel and as unselfish as a saint. Besides, electromagnetic induction was so wonderful, destined, as he says, "to form a new era in the history of electricity and magnetism," that he would not permit himself in so big a thing as that to stand as a rival of the great Faraday.

Fifty-one years ago I first saw Henry's discovery. At that time I was a student at Columbia, very fond of Greek and Latin, so fond of it, in fact, that I devoted most of my time to the study of Greek and Latin and classical literature. At the same time I was fond of mathematics and of physics and of chemistry, and there was a doubt in my mind whether, when I graduated, I should take up classical studies or physics as my life work. One day I saw an experiment performed in the lecture room by the late Professor Rood of Columbia. He had a coil of wire, the terminals of which were connected to a galvanoscope, which was attached to the side of the wall in order that the class could see the movement of the magnetic needle. The coil was in his left hand and a magnet in his right. He moved the magnet a little bit, and off went the needle to one side; and then he moved the coil back, and the needle moved in the opposite direction. It is generally believed that the magnetic needle moved because it was acted upon by the passage of electricity through the coil. Be that as it may, that needle, I am sure, was never as much thrilled as I with that experiment, and I said "Good-bye Latin, good-bye Greek, I am going to study physics."

Imagine how young Henry felt when he saw that magnetic needle thrill for the first time in the history of man as he moved the magnet in his modest laboratory at the high school in Albany. He himself tells what he thought of it—that it was destined to form a new era in the history of electricity and magnetism. It is obvious why this man, who was as modest as an angel and as unselfish as a saint, could not thrust himself forward to dispute the discovery with a man as great as Faraday was at that time.

The same modesty and the same unselfishness which Henry displayed with regard to his claim as independent discoverer of electromagnetic induction, we find again in the case of his invention of the electromagnetic telegraph. Innumerable schemes had been proposed by various men, and at various times, to transmit signals by electricity. Even the electromagnetic scheme was originated in many minds and at various dates subsequent to Oersted's discovery, but nobody understood the problem as well as Henry, and nobody succeeded in solving it until he himself found a solution in 1831. Barlow was one of the originators, but the distinguished physicist admits his failure when he says, in 1825: "I found such a sensible diminution (of the magnetic force) with only two hundred feet of wire, as at once to convince me of the impracticability of the scheme."

Wheatstone, another originator of the electromagnetic telegraph scheme, says this, in 1837: "It would not act, and could not act as a telegraph, because sufficient attractive power could not be imparted to an electromagnet interposed in a long circuit."

Wheatstone was not aware, in 1837, that Henry had demonstrated the practicability of the scheme in 1831, and that he wound up the description of his experiments in *Silliman's Journal*, by saying: "The fact that the magnetic action of a current from a trough is at least not sensibly diminished by passing through a long wire, is directly applicable to Mr. Barlow's project of forming an electromagnetic telegraph."

Henry's success is due to his complete understanding of Ohm's Law, discovered in 1827. Barlow did not understand it because it had not been formulated when he made his telegraphic experiments in 1824, and Wheatstone did not understand it in 1837, because the law was formulated in Germany, and Wheatstone was an Englishman. Henry had no international prejudices. Ohm's Law, furthermore, was not the only thing involved in a complete understanding of the electromagnetic telegraph problem; the self-inductive reaction of the electromagnet, and of the long line, had to be adjusted, and Henry worked to make the resistance of the line and the self-inductive reaction of the line small in comparison with the resistance and the self-inductive reaction of the electromagnets. In other words, he used an intensity magnet and intensity battery when working over a long line. This is the alpha and the omega of the electromagnetic telegraph, and it belongs to Henry and to nobody else.

If the principle is true that that man is the inventor who first constructs and describes an invention in such a way that anybody skilled in the art can put the invention into practical use, then surely Henry is the real inventor of the electromagnetic telegraph. But Henry with his boundless modesty calls it Mr. Barlow's project, and never lays any claim to it. He even recommends, in 1856, that an extension of Morse's patent be granted to Morse.

It is easy to understand the motives which prompted me twenty-two years ago to back with all my heart and soul the proposition, first advanced by my honored colleague, Professor F. B. Crocker of Columbia University, that the unit of self-induction be named after Henry. The Congress of Chicago adopted this proposition; and it is a significant fact that the motion was made by an Englishman, Ayrton, and seconded by a Frenchman, Mascart, while the presiding officer was a German, the great Helmholtz himself.

In 1842 Henry described before the American Philosophical Society his wonderful discovery of electrical oscillations accompanying a Leyden jar discharge. He traced the magnetic action of these oscillations at a distance of thirty feet, transmitted through the walls and floors of a house, the detector being a steel needle magnetized by the transmitted oscillations. In this lecture Henry said: "The author is disposed to adopt the hypothesis of an electrical plenum, and from the foregoing experiments it would appear that the transfer of a single spark is sufficient to disturb perceptibly the electricity in space throughout at least a cube of 400,000 cubic feet of capacity; and when it is considered that the magnetism of the needle is the result of the difference of two actions, it may be further inferred that the diffusion of motion in this case is almost comparable with that of a spark from flint and steel in the case of light."

Who does not feel in reading these lines that Henry knew instinctively that he was facing here a problem containing boundless possibilities? I am sure that he saw before him wireless telegraphy and the electromagnetic theory of light. There was no topic that he loved to discuss with his friends as much as the oscillating discharge of a Leyden jar. I can imagine how a man of his years (he was only forty-three at that time), and of his accomplishments, must have been eager to throw himself heart and soul into the study of the great and fascinating problem which he himself had formulated.

But unfortunately for his own scientific work, after fourteen years of experimentation and academic duties at Princeton, Henry went to Washington to organize the Smithsonian Institution. He knew that this meant both an adieu to science for many years to come, and a bitter fight with crafty lawyers and cunning politicians who were eager to get hold of the Smithsonian Foundation, and to fight about what Smithson meant when he said that the foundation had been established for the purpose of advancing science and diffusing knowledge. The lawyers maintained that Smithson meant to build libraries and fill them with law books; and the politicians said that Smithson wanted to buy seeds and send them to farmers, through the medium of the Representatives—a wonderful way to secure new votes for Congressmen and Senators.

In spite of the craftiness of lawyers and the cunning of politicians, Joseph Henry won out in the long struggle because he had on his side both justice and Joseph Henry. The Smithsonian Institution was organized in accordance with his ideals, and is today both a splendid research laboratory, and a splendid museum. From the Smithsonian Institution, nurtured by Joseph Henry, sprang the magnificent scientific bureaus in Washington. He helped organize the American Academy of Arts and Sciences, but above all he was the inspiration of the scientific spirit in Washington.